

MULTISPECTRAL BEHAVIOUR AND MIXING MODEL SIMULATIONS OF EUROPEAN TERRAINS FROM GALILEO IMAGES. Beth E. Clark (Cornell, beth@astro.sun.tn.cornell.edu), P. Helfenstein (Cornell), J. Veverka (Cornell), P. Geissler (LPL), M. Bell (Cornell), R. Greeley (ASU), R. Sullivan (ASU), T. Denk (DLR), A. S. McEwen (LPL), C. B. Phillips (LPL), and the Galileo Imaging Team.

INTRODUCTION

Galileo's Solid State Imaging camera (SSI) recorded six multispectral images of Europa's north polar region during the G1 tour at a resolution of 1.6 km/pixel at wavelengths centered at 416, 559, 664, 757, 888, and 989 nanometers. We have photometrically corrected these data using the Domingue et al. (1991) Hapke function [1] derived from groundbased and Voyager data, and extracted spectra from distinct European terrains. We find that the "darkest" materials on Europa lie along the triple bands and that the brightest materials lie among the icy bright plains. With these extreme terrains as endmembers, we use a linear mixing model to reproduce the spectral behaviour of Europa's Mottled and Dark Spot terrains to within 5%, confirming results by [2]. Of note are the particular cases where linear mixing between reasonable endmembers does not work.

SUMMARY OF OBSERVATIONS

(1) Dark Lineaments (Minos and Cadmus) are spectrally redder, darker, and have shallower absorptions at 1 micron than the surrounding icy Bright Plains (see Figure 1). Although these lineae are termed "dark" [1], we note that their average normal albedos are 0.9, compared to the surrounding Bright Plains at 1.4. (Note that albedo values are greater than 1.0 in this case because we are using a global average photometric function and extrapolating to zero phase, a procedure which may not take into account differences in photometric parameters (such as the opposition surge) between terrains on Europa. Compositionally, these units are consistent with H₂O ice contaminated by an unknown spectrally red and darker non-ice component [3,4].

(2) The Bright Plains unit described from studies of Voyager data [5,6] can now be subdivided on the basis of their spectral behaviour at the SSI infrared wavelengths, 888 and 989 nanometers, into the IR-Bright and the IR-Dark Plains Units (see Figure 1). IR-Bright regions are spectrally darker in the visible and brighter in the IR. These spectral differences are not consistent with a simple grain size change between terrains, but may be due to a combination of grain size differences, the effects of varying exposure times to bombardment (by magnetospheric ions) at the surface [3], and/or compositional differences. Such bombardment has been suggested to result in darkening in the visible, hence indicating that the IR-Bright regions are perhaps older than the IR-Dark plains. However, examination of the areal extent and relationship between these units shows that this interpretation is unlikely [7]. It is more likely that grain size and/or compositional differences cause the spectral differences between the icy plains units.

(3) Mottled areas and Dark Spot regions have spectra which are intermediate in color and albedo between the Bright Plains units and the Dark Lineaments, confirming Voyager results (see Figure 1).

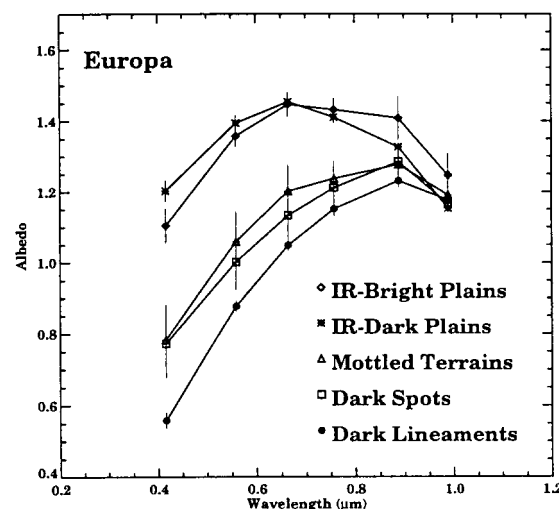


Fig. 1. Multispectral behaviour of European terrains.

(4) Cross-cutting relationships among Dark Lineaments allow study of the changes in albedo and spectral behaviour of the Dark Lineament materials through time. There is strong evidence that these materials increase in albedo and in absorption band depth at 1 micron with increasing age. In places there is the suggestion that stratigraphically old tripleband lineaments are "fading" in contrast into the surrounding IR-Dark icy plains [8].

SUMMARY OF MIXING MODEL

We performed a simple areal linear mixing model using spectra of the distinct terrains summarized above. The question we ask is "Can we explain the intermediate albedo units on Europa as areal mixtures of the two extreme albedo endmember units visible on the surface?" The answer is yes, in most cases. In the instances where linear mixing does not work, it is possible that: (1) the endmembers are inappropriate, (2) the components are intimately mixed, or (3) more than two endmembers are needed. Both of the icy Plains units were available as endmembers, although we used only one at a time in the model simulations. For the dark endmember we chose the darkest material available on the surface—the dark sides of the triplebands. Results include:

(1) Dark Spot terrains can be simulated equally well with mixtures of the IR-Bright plains or the IR-Dark plains with dark tripleband materials. Both mixes match to within 4% in albedo. Individual dark spots vary in albedo by much more than 4%.

(2) Freckle terrains can be simulated best with mixtures of IR-Dark plains and dark materials.

(3) Mottled terrains can be simulated equally well with mixtures of the IR-Bright plains or the IR-Dark plains with

dark tripleband materials. However, not surprisingly, Mottled areas within the IR-Bright units cannot be simulated using IR-Dark icy plains materials.

(4) Stratigraphically older triplebands can only be simulated with IR-Bright icy plains and dark tripleband materials (see Figure 2).

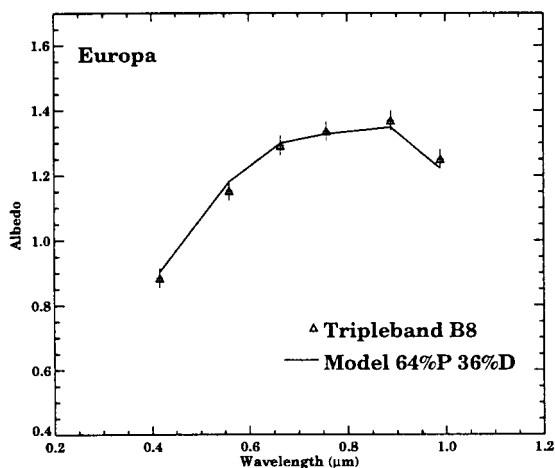


Fig. 2. Linear mixing model simulation of a stratigraphically old tripleband using a mixture of IR-Bright icy plains and dark tripleband side material spectra. The model spectrum is a mixture of 64% icy plains and 36% dark tripleband. Models using the IR-Dark icy plains materials as an endmember did not result in a good spectral match to within 15%.

CONCLUSION

The fact that aging triplebands are best simulated by mixtures of the IR-Bright plains units and dark tripleband materials suggests that the triplebands and the IR-Bright terrains may have grain size (texture) or compositional similarities to each other. If the triplebands are fated to fade into the surrounding plains with increasing age, they may have to become darker in the IR while simultaneously becoming brighter in the visible. Work is underway to define a surface aging process which would produce these effects.

REFERENCES

- [1] Domingue et al. (1991) *Icarus*, 90, 30. [2] Lucchitta and Soderblom (1982) in *Satellites of Jupiter*, UofA Press, 521. [3] McEwen (1986) *JGR*, 91, 8077. [4] Buratti and Golombek (1988) *Icarus*, 75, 437. [5] Johnson et al. (1983) *JGR*, 88, 5789. [6] Malin and Pieri (1986) in *Satellites*, UofA Press, 689. [7] Phillips et al. (1997) this volume. [8] Geissler et al. (1996) *EOS*, 77, F438.

ACKNOWLEDGMENTS

We gratefully acknowledge the help of Brian Carcich and Jonathan Joseph. This research is supported by the Galileo Project under JPL contract number 958504.